

WBS 1.2 Pixel Resource Loaded Schedule

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Introduction

- Schedules prepared with no staging: build complete pixel detector
- Meeting with Procurement Dept
 - Assumes that preproduction and production for sensor, ROC, HDI, and hybridization are linked; production is an option to produce more based of satisfactory results from the preproduction
 - > Same vendors, no fresh round of bidding for production
- Schedule assumes that
 - ➤ Money will be available in FY05 and FY06 for these key purchases (including labor).
 - Find out that we also need to move faster on the substrates procurement and fabrication
 - ➤ Net result is about 11 months of float
- Methodology:
 - ➤ Use detector READY-BY and NEED-BY date. Difference = Float

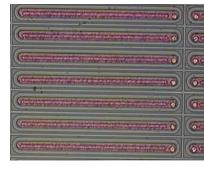


Pixel Detector

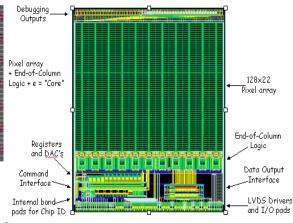
WBS 1.2

- Pixel Sensor bump-bonded to Readout chip
- Fine segmentation
 - > 50 μm x 400 μm
 - ➤ Large number of channels
 - Electronics in the active tracking volume
 - High power density (cooling system)
- Basic building block Multichip Module (MCM)
 - Large number of HDI and flex cables
- Assemble modules on substrate to form pixel half plane; an xmeasuring half-plane and a ymeasuring half-plane form a halfstation

Si pixel sensors

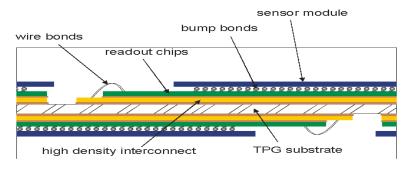


Pixel Readout chip



Multichip module







Pixel Half-Station

WBS1.2

The temperature control elements modulate the temperature of the substrate



Carbon support half cylinder (~1.26m long)

Carbon fiber bracket

PGS (Pyrolytic Graphite Sheet) flexible thermal coupling attached to copper tab LN2 heat sink

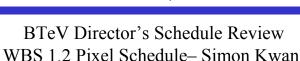
TPG

(Thermal Pyrolytic Graphite)

Carbon fiber spacer

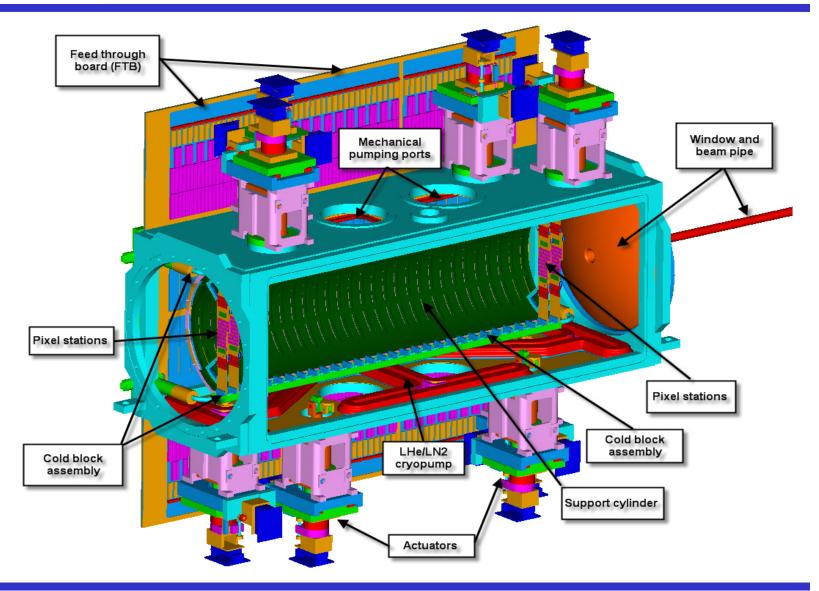
Pixel modules placed on both sides of the TPG substrate (active region: ~10 cm long)

Precision hole & slot washers





Pixel Detector Assembly



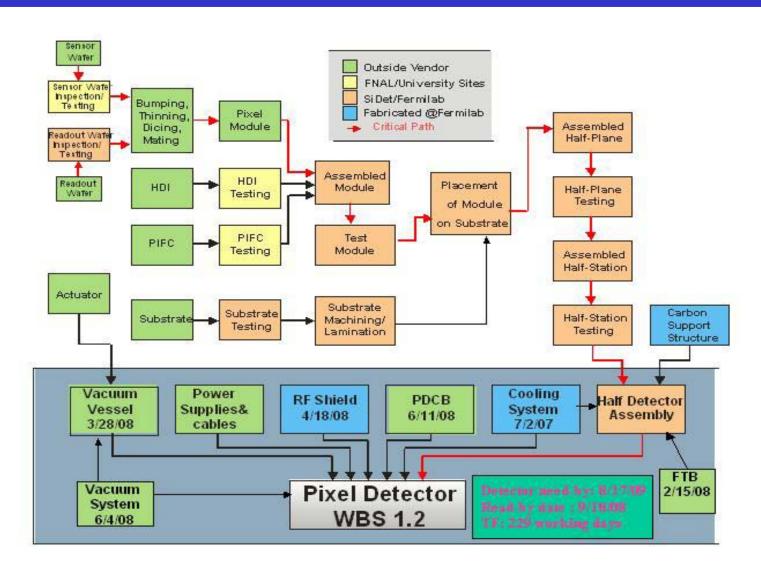


Pixel Schedule Overview

- Assumes that assembly of modules, half-plane (half stations) and half detector assembly will be done at SIDET
- SIDET has unparalleled infrastructure (Wire bonding machine, CMMs, probe stations, microscope, repair stations) and pool of experienced technical staff
- Significant expertise with carbon fiber at Lab 3 (carbon fiber support structure, brackets, lamination of TPG) and cryogenics & vacuum system in PAB and Mechanical Department
- Years of prototype experience and quite a few iterations of key components
- End point defined by Tevatron shutdown for FY09: 8/1/09 (was 6/1/09)
- Installation requires that pixel be ready by: 8/17/09 (was 5/4/09)
- Pixel installation has to occur before forward tracker; Pixel is critical path item
- Schedule estimate based on communication with vendor, prototype experiences and engineering estimates based on other similar projects. It does not skip any steps (prototype, preproduction, production); but production design cycle shortened (contingency increased to cover any added labor cost if needed)
- Preproduction precedes production and assumes that we don't have to go through any bidding process; production is a continuation of the preproduction
- Schedule contains no explicit slack; task duration reflect nominal need for task completion









Key Milestones (old vs new)

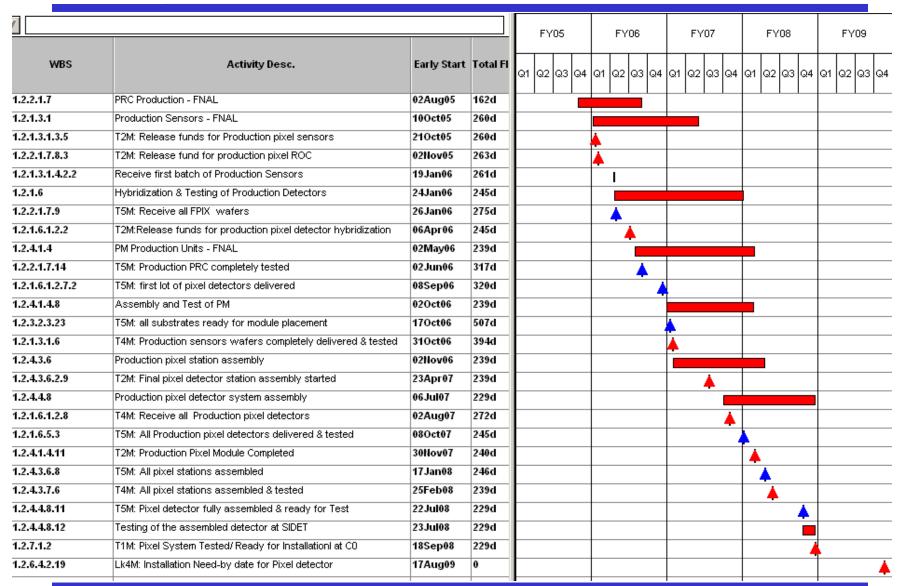
Milestone	Old (CD1) date	New (post-CD1) date
PO for production sensors	Feb 2006	Oct 2005
PO for production pixel readout chips	July 2006	Nov 2005
PO for detector hybridization	Feb 2007	April 2006
Final detector assembly started	Nov 2007	March 2007
All pixel detectors delivered & tested	March 2008	Oct 2007
Pixel modules completed	May 2008	Dec 2007
Pixel detector ready for installation	Feb 2009	Sept 2008



- Detector need-by date: August 17, 2009
- Scheduled completion date: September 18, 2008 giving a total float of
 working days
- Pixel Detector will be installed as one piece (vessel with stations inside)
- Pixel Detector has many components but the critical path is the making the pixel modules, placing them on a substrate (half-plane and half-station), and assemble the half-stations into the two half-detectors. This is a sequence of assembly and testing steps. Because we have 1380 modules in total, the duration of the each sequence is long (10 months or more). To keep this tight schedule,
 - ➤ A lot of staggering in the activities
 - ➤ Place the orders early (sensor, ROC, hybridization)
 - ➤ Multiple paths/vendors
 - > Sustain the flow of parts and have more than one assembly/test line/shift
 - > Engage qualified vendors early in QA and throughput discussion



Critical Path Gantt Chart





Bump Bonding

- The real critical path is bump-bonding. We have not had a large enough contract with any vendor to certify the automation of the flip-chip assembly process -> importance of preproduction and doing this early
- In the CD1 review, reviewer made the following comments:
 - > Schedule was too aggressive
 - \triangleright Time from start of bump bonding to all detectors tested should be \sim 18 months (we had 13 months)
 - \triangleright Time from start of bump bonding to completion of detector ~ 2.5 years (we had 2 years)
 - Recommended to find ways to gain 6 months
 - ➤ We have done this by placing the contracts early (sensor, ROC, and hybridization)
- Robustness checks



Schedule Robustness

- Schedule contingency
 - ➤ Placed before key milestones or activities
 - ➤ Nominally zero duration
 - ➤ Can change duration to check robustness of schedule

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	Milestone	Normal	Sensor	ROC	Hybridization	Pixel module
		schedule	delivery	procurement	delivery	assembly/testing
			(+60d)	(+30d)	(+100d)	(+50d)
	PO for Pixel sensor	10/21/05	ņc	ņc	nc	nc
	PO for ROC	11/2/05	ņc	12/15/05	ņc	nc
	PO for hybridization	4/6/06	ņc	4/24/06	nc	nc
	Sensor wafers	10/31/06	1/29/07	10/31/06	ņc	10/31/06
	completely					
	delivered & tested					
	Receive all	8/2/07	ņc	8/20/07	12/26/07	8/2/07
	hybridized pixel					
	modules from					
	vendor					
	Pixel assembly	4/23/07	nc	5/1/07	7/27/07	4/23/07
	started					
	Pixel modules	12/1/07	nc	12/10/07	3/11/08	2/14/08
	completed					
	All pixel stations	2/25/08	nc	3/4/08	5/29/08	5/2/08
	assembled & tested					
	Pixel detector	9/18/08	nc	nc	12/10/08	11/12/08
	READY for		***			
	installation					



Schedule Robustness

BTeV - WBS 1.2 Pixel Detector Total Construction Obligation Profile (FY05\$K) by Institution & Fiscal Year Fermilab Labor: Salary, OP TO, Vacation, Pringe & Overhead Non-Fermilab Labor: Salary, Benefits & Overhead Contingency Not Included, Material Burdened Planted Critical Late Date Milestone Progress Summary Float												
Activity ID	Activity Description	iginal Duratio	Early Start	Early Finish	Hoat	FY04	FY05	F Y 0 6	F Y07	FY08	FY09	
32253	SC:Substrate design schedule contingency	0	11Aug05	11Aug05	294d		32253		Į			
13.135	T2M: Pekase funds for Production pixel sensors	0	21Oct05	21Oct05	143d		13.135					
2.1.7.8.2	SC: Production PRC schedule contingency	30:1	02 No v05	15 Dec05	116d	2.17.8.2						
2.1.7.8.3	T2M: Release find forproduction pixel ROC	0	15 Dec05	15 Dec05	116d	2.1.7.8.3						
2.1.7.9	T5M: Pecelve all FPIX wafers	0	09 Mar06	09 Mar06	128d		2.1	7.9 🚐				
1.5.122	T2M:Release fluids for production pixel defector hybridization	0	24Apr06	24Apr06	116d		1.6	.1.2.2 /	Į.			
3.5.2.10.3	SC:Cooling system destji solednih contingency	0	04Aug06	04Aug06	286d		3	62.103		ļ		
1.3.1.5.3.7	SC: Production sensor schedule contingency	60d	31Oct06	29Jan07	2 17 d			1.3.1.5.3.7	Z 	Ę.		
1.3.1.6	T4M: Production sensors wanters completely delibered & tested	0	29Jan07	29Jan07	2 17 d			1.3.	1.5	<u> </u>		
13.52.8	SC: Pike I station assembly startschedule contingency	0	14Aug07	14Aug07	160d	↓3.5.2.8 — -						
43.52.9	T2M: Final pixel detector station assembly started	0	14Aug07	14Aug07	160d				13529	—		
1.5.1.2.7.5.4	SC: Productor pixel detector assembly schedule contagency	100:1	20 Aug 07	15Jan08	116d			1.6	12754			
1.6.1.2.8	T4M: Pecetre all Production pixel detectors	0	15Jan08	15Jan08	116d				1.5.1.3	2.8		
4.1.4.10	SC: Productor pixel module assembly/fest schedule contingeroy	450	27 Mar08	29 May08	116d				4.1	.i.10 🗁	7	
4.1.4.11	T2M: Production Pixel Module Completed	0	29 May08	29 May08	116d				1	.1.4.11	-	
13.7.5	SC: Pikel station assembly schedule contingency	0	18 Aug 08	18 Aug 08	116d					4.3.7.5	二	
4.3.7.6	T4M: All pixel stations assembled & tested	0	18 Aug 08	18 Aug 08	116d					4.3.7.6 4 5	-	
7.1.2	TiM: Pikel System Tested/ Ready for installation lat CO	0	05 Mar09	05 Mar09	116d					7	.12 🚍	
6.4.2.19	Lk 4M: Installation NeedHoy date for Pixel defector	0	17 Aug 09	17 Aug 09	0						6.4.2.19 v A	

Activity ID	Activity Name	Base Cost (\$)	Contingency	Labor Contingency (%)	Total Cost (\$)	Total FY05	Total FY06	Total FY07	Total FY08	Total FY09	Total FY05-09
1.2.1	Sensors and Pixel Detector Hybridization	2,244,262	47	32	3,251,349	604,896	2,494,553	148,932	2,968	0	3,251,349
1.2.2	Pixel Detector Electronics	4,180,018	37	39	5,741,872	740,583	1,774,960	1,060,929	2,165,400	0	5,741,872
1.2.3	Mechanical Cooling and Vacuum System	4,551,504	46	38	6,438,543	361,422	2,391,748	2,342,369	1,343,005	0	6,438,543
1.2.4	System Integration & Testing	3,587,917	48	47	5,272,247	386,273	961,807	2,389,974	1,207,973	326,219	5,272,247
1.2.5	Pixel Detector Subproject Management	799,673	23	18	945,962	189,949	192,976	190,706	190,706	181,625	945,962
1.2	Subproject 1.2	15,363,375	43	39	21,649,973	2,283,124	7,816,045	6, 132,910	4,910,051	507,844	21,649,973

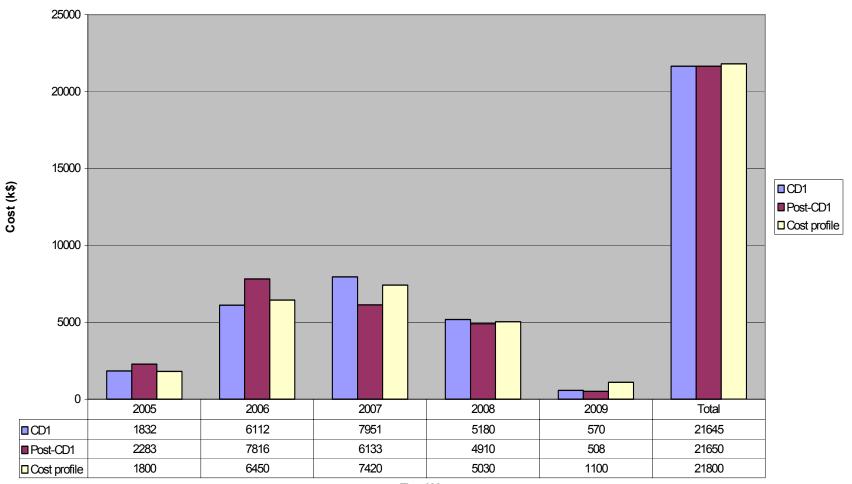
For comparison:

CD1 cost: base – \$15.46M, Contingency: \$6.19M Total \$21.65M

Cost Comparison with CD1

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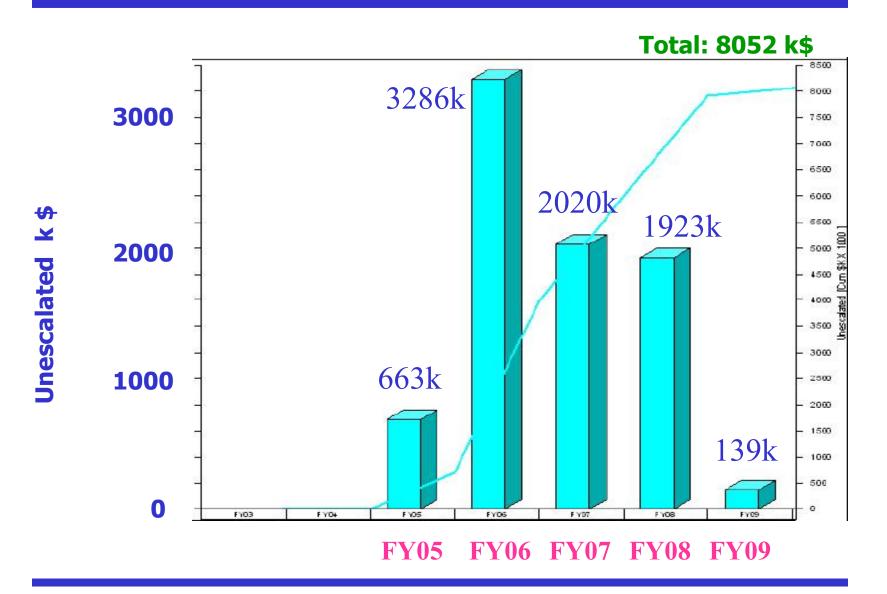
Total Construction Cost Comparison



Fiscal Year

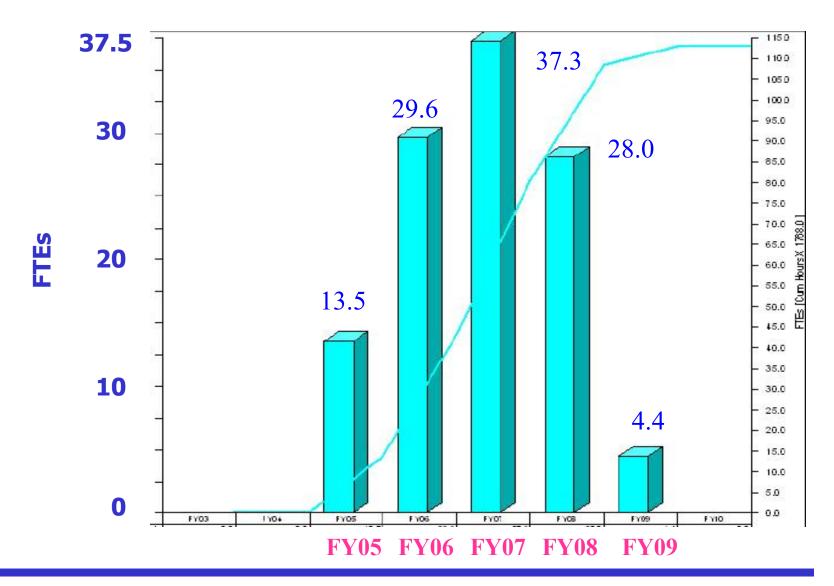


M&S Obligation Profile by Fiscal Year WBS 1.2





Labor Profile by Fiscal Year WBS 1.2





Responses to CD1 recommendations

- Develop more conservative schedule with significant more float (> 6 months)
 - ➤ We have followed their recommendation. By moving a few procurements forward and move back the detector need-by date, we have achieved a float of about 11 months.
- Evaluating options for relaxing the funding profile constraints to achieve a more conservative approach
 - > DONE
- Evaluate schedule and performance impact of staging options
 - While we believe that the experiment will work with an efficiency of about 60% with say ½ of the pixel stations, to complete the installation of the other half of the pixel detector will lead to a long shutdown, estimated to be about 6 months or longer and with considerable risk to the forward tracking stations (which need to be removed first before the pixel vacuum vessel can be taken out). After careful consideration, we think that it's better to assign resources to guarantee the completion of the pixel detector on schedule and not pursue the staging option.